RELEASING FOUR-YEAR-OLD PINES IN MIXED SHORTLEAF-HARDWOOD STANDS [1]

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Abstract. At age 4, planted shortleaf pines (*Pinus echinata* Mill.) were released in pine-hardwood mixtures on medium quality upland sites. Over the next 2 years, height and diameter growth of pines and height growth of hardwoods were observed. Height growth estimates indicate that the pines are successfully establishing themselves in the overstory without the help of release. At the same time, reducing hardwood competition did enhance pine diameter growth. Specifically, the spring felling of competing hardwoods increased 2-year pine diameter growth by 17 percent over the no-treatment control, and a winter felling and herbicide treatment increased diameter growth by 22 percent.

Introduction

Deliberate regeneration of pine-hardwood mixtures is a new idea that shows promise in the Southern Appalachians and Piedmont Plateau of the Southeastern United States (Waldrop and others 1989). On upland sites of medium quality where hardwoods have become established, intensive site preparation and pine plantation management can be prohibitively expensive for many forest landowners. A regeneration system called "fell-and-burn" (Abercrombie and Sims 1986, Phillips and Abercrombie 1987) has been developed and extensively used in the mountain and foothills region of South Carolina. If management objectives include hardwoods for wildlife, firewood, and aesthetic benefits as well as pines for timber production, then stands regenerated with this system will develop satisfactorily with no further treatment. However, some owners are interested in increasing pine volume and would like to know how well the pines will respond to release from hardwood competition. The long-term objectives of our study are to compare pine survival and growth in mixed pine-hardwood stands in which pines are and are not released.

The pine-hardwood stands used in this study are products of the fell-and-burn system developed and extensively used on the Andrew Pickens District of the Sumter National Forest in the mountain and foothills region of South Carolina. The sites on which this system is practiced are generally south- to southwest-facing slopes with site indices for oaks of 55 to 65 ft at age 50. The system consists of a commercial clearcut, spring felling of the residual stems, a summer fire to knock back the coppice regrowth and reduce logging slash, and interplanting of shortleaf pine (*Pinus echinata* Mill.) on sites with elevations

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above 1000 ft. The summer burning is done over a wet forest floor so as not to consume the 3- to 6-inch root mat (0_e and 0_i layers) characteristically found on the sites. This organic layer protects against soil erosion and helps facilitate high survival of planted shortleaf pines by improving soil moisture in the rooting zone. With a high survival rate, the 10-ft by 10-ft spacing called for on the Andrew Pickens district yields a large, uniform pine component in the developing stands.

Methods

The three stands selected for study were harvested during the 1980-81 dormant season. Residual stems taller than 6 ft were felled after leaf-out in the spring of 1981. The sites were summer-burned in 1981 and planted with graded, 1-year-old shortleaf pine seedlings during the 1981-82 dormant season. Two types of plots were laid out during the 1985-86 dormant season (after four pine growing seasons). First, in each stand six 52.5-ft by 82-ft plots (hereafter called treatment plots) were laid out in a two plot by three plot pattern. Plots were separated with 16.4-ft buffer strips. Superimposed on the treatment plots were nine 9.8-ft by 121.4-ft strip plots (hereafter called initial inventory plots) whose long dimension was oriented across contiguous treatment plot pairs. The initial inventory plots were used to estimate average heights and stem densities per acre by species before treatments were imposed.

After the initial inventory, all planted pines within each of the 18 treatment plots were identified with a numbered tag and basal diameter 1-ft above the ground and total height were measured. Before the treatments were installed, all woody stems within 5 ft of each tagged crop pine were counted, identified by species, and measured for total height (only the tallest stem in each sprout clump) and distance (to the nearest ft) from the crop pine. Inclusion within the 5-ft radius was based on the location of the stump for sprout clumps or the stem groundline location for advanced regeneration, not the location of the crown projection.

Three treatments were randomly assigned (three treatments to six plots at three locations) and installed during the 1985-86 dormant season (when the pines were 4-years-old) following both the strip inventories and the hardwood stem measurements around the crop trees. The treatments were: (1) control (no release), (2) spring felling of competing hardwoods in a specified radius of each tagged pine, and (3) winter felling in the same way as the spring felling followed by application of a herbicide to all stumps. The herbicide was Garlon 3A™ prepared as a mixture of one part Garlon to two parts water applied to stumps in late winter (February 2 to March 31) within 7 days of the stem felling. The study plan called for felling all hardwoods within 5 ft of each crop pine. However, research technicians were not available when treatments were to be installed, so a commercial contractor was used instead. The practice of the commercial operator was to ocularly estimate distance. A follow-up check showed clearing radii generally fell between 3 and 5 ft. The treatment plots were remeasured 2 years after treatment in the same way as before treatment.

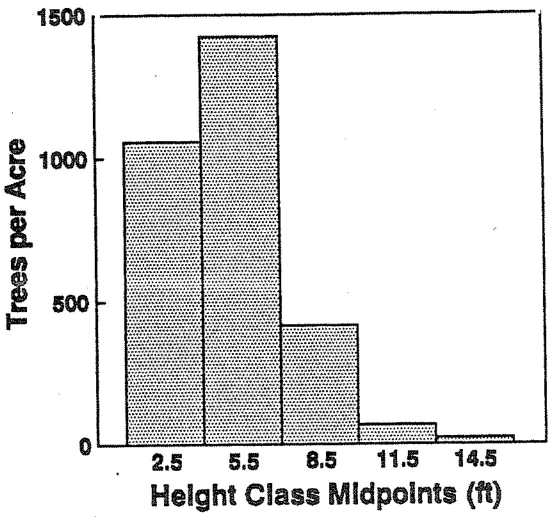

Figure 1. Hardwood height frequency distribution at age 4 (inventory plots).

Results And Discussion

At the beginning of the study, the average height of pines exceeded the average heights of oaks, "fast starter" hardwoods, and other woody stems (Table 1). However, the frequency distribution of hardwood heights in Figure 1 shows that the average hardwood heights in Table 1 are misleading in that they are made up of large numbers of small stems. The size distribution shows the presence of approximately 500 hardwood stems that were 8.5 to 14.5 ft tall. The weighted average height of these larger hardwoods is 9.1 ft. In other words, a fairly dense stand of large hardwoods averaged 2.28 ft of height growth per year prior to treatment installation, while pines averaged 2.13 ft per year during the same period.

Table 1. Estimated number of stems per acre and mean stem height (only the tallest stem when in sprout clumps) from inventory of strip-plots prior to treatment.

Species group	Number of stems per acre	Mean stem height
	--- (number) ---	--(ft)--
Planted shortleaf	349	8.5
Oaks	730 [b]	5.6 [d]
Fast starters[a]	203 [b]	7.5 [d]
All other woody stems	2033 [b,c]	4.6 [d]
Total	3317	

[a] Includes black cherry, red maple, and sourwood.
[b] Total number of hardwood sprouts and seedlings.
[c] Includes volunteer shortleaf pine.
[d] Weighted average height is 5.0 ft using the number of stems for the three hardwood groups.

Remeasurement of treatment plots during the 1987-88 dormant season provides data on growth of pines and hardwoods near them (Table 2). From age

4 through age 6, pines maintained their height growth, while experiencing only 0.3 percent mortality. Average annual height increment for pines before treatment (using all plots) was 2.16 ft/yr, while annual increment averaged 2.25 ft/yr between ages 4 and 6 on both the control plots and the released plots. This outcome would be unlikely if the pines were being overtopped by the hardwoods.

Table 2. Average pretreatment (1985-86 dormant season) and post-treatment (1987-88 dormant season) heights for crop pines and three hardwood subsets.

	Pretreatment- age 4			Post-treatment- age 6		
	Pine	Hardwood tallest within:		Pine	Hardwood tallest within:	
Treatments		3 ft	5 ft		3 ft	5 ft
	(ft)					
Control	8.9	6.3	9.0	13.4	8.1	10.7
Spring fell	8.6	5.8	7.9	13.0	5.3	6.9[a]
Winter fell -herbicide	8.4	5.7	8.1	13.0	4.4	6.2[a]

[a] Some trees in these average heights were not felled at the time of treatment.

The hardwood height data support the assertion that the unreleased pines are successfully competing with the hardwoods. We arbitrarily defined a "tallest" subset of hardwoods as those on the 0.1-ac treatment plots (43 trees) whose stem count per acre equaled the planted pine density of 436 seedlings/ac. Table 2 presents the average height of these tallest 43 hardwoods on each treatment plot within a 3-ft radius and a 5-ft radius of the crop pines. At age 4, the tallest hardwoods within 3 ft of pines averaged 2.40 ft shorter across all treatments than the tallest hardwoods within the larger radius (these data were taken before the felling treatments were installed). The trend was similar (2.70 ft) at age 6 (control plots only).

Another perspective on relative competition is gained by comparing average annual height increment of hardwoods on the control plots before age 4, when the hardwoods were more free to grow, with growth after age 4 (Table 2). Prior to age 4, the tallest hardwoods within 5 ft of pines on the controls averaged 2.25 ft/yr, but their height growth between age 4 and 6 slowed to 0.85 ft/yr. This slowing occurred while pine height growth was steady to slightly increasing for the pines. There are other possible explanations for the reduced hardwood growth, like decreasing sprout vigor, but increasing competition is also a plausible explanation. Given the size of the pines, much of this competition could be from them. Any of the above points, alone, is not conclusive. Taken together, however, the results indicate that a vigorous pine component will be established in the developing overstory without release.

Height growth and diameter growth of pines in the 2 years after treatment were analyzed for differences between treatments as a Randomized Complete Block (RCB) design. Analyses of variance on height growth showed no variance component due to locations (no differences in height growth between locations) and no significant differences between treatments. We expect location effects on height to eventually be significant because of site quality differences, but this variation is removed from the statistical comparison by the RCB design. The lack of treatment effect on height growth was expected.

Table 3 shows diameter growth between ages 4 and 6. Both the location variance component and the test statistic for treatments were statistically significant. The location effect is probably caused by differences in stand density, but we did not attempt to verify that possibility. Two-year pine diameter growth for the spring felling release treatment was 17 percent higher than the control (Table 3). Felling in the winter and spraying with herbicide added 5 percent more growth over the spring felling treatment. Both increases were statistically significant.

Table 3. Average basal diameter (1 ft aboveground) increment of the crop pines between age 4 and 6.

Treatments	2-year diameter increment	Percent increase over control
	-----(inches)-----	---(percent)----
Control	0.92	
Spring fell	1.08	17
Winter fell-herbicide	1.12	22

Conclusions

There is strong evidence from these short-term results that the pines in these mixed stands do not need to be released to remain competitive. The hardwoods are not likely to shade them out. At the same time, pine diameter growth responded strongly to reduced competition. It remains to be seen how long the diameter response will be maintained. Understanding these long-term changes will require measurement of growth of all woody vegetation on the plots, not just the hardwoods within 5 ft of the crop pines.

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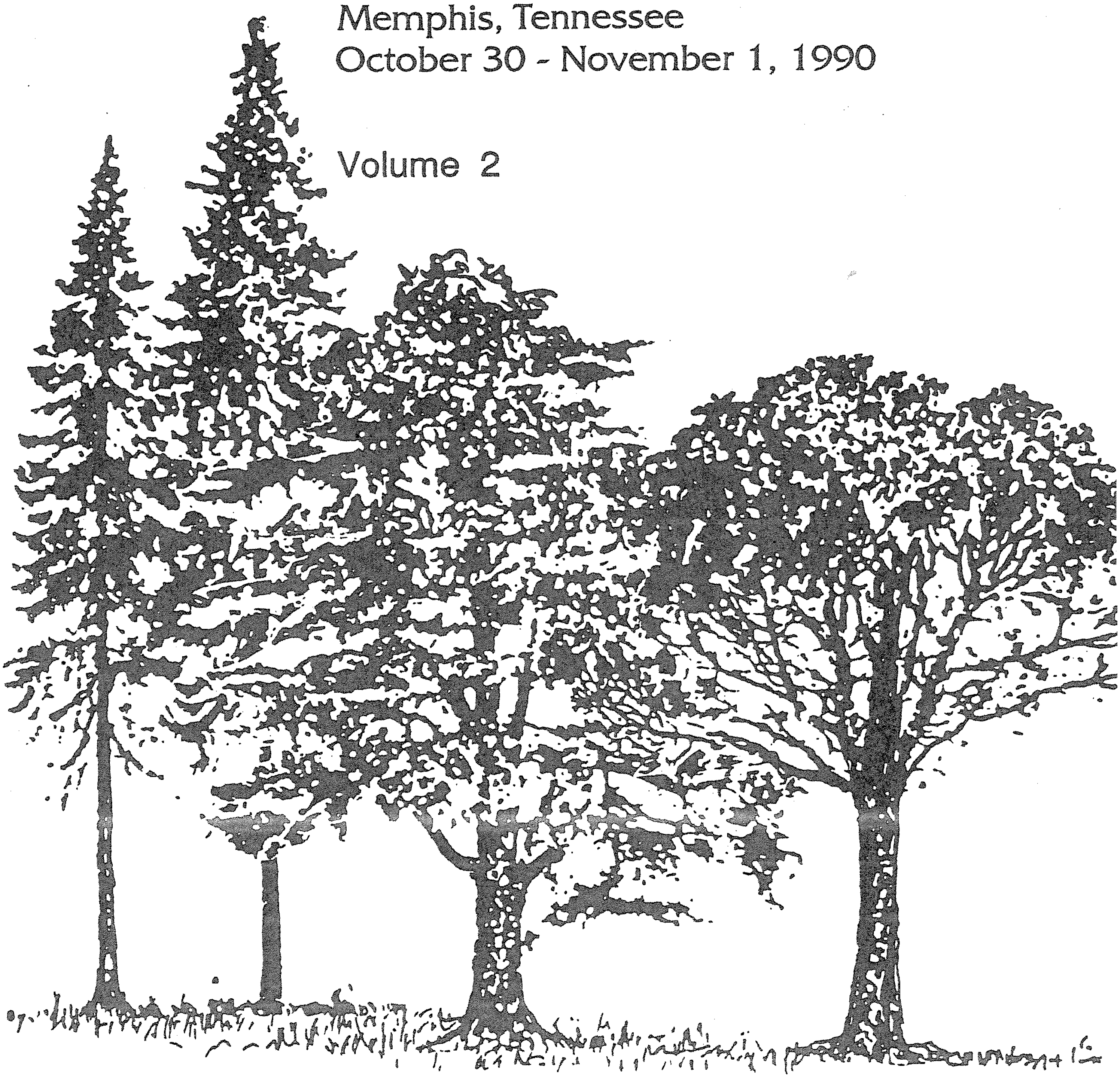

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